

# Assessment of anesthetic gases in a central hospital

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## Abstract

**Introduction:** Adverse health effects related with chronic exposure to waste anesthetic gases remain controversial. Strict threshold values are recommended to minimize possible health risks. The objective of our study was to measure the concentration of waste anesthetic gases in different hospital settings in an 11-year period.

**Materials and methods:** Six-monthly assessment of nitrous oxide, sevoflurane, and desflurane was made between 2005 and 2016 in different hospital departments. Trace gas analysis was performed by infrared spectroscopy.

**Results:** An anesthetic gas concentration above the upper limit of the threshold value was found in computed tomography/magnetic resonance imaging (CT/MRI) (45.5%), ambulatory operating room (34.5%), and in the burn unit (31.6%). Desflurane assessment was more frequently above the upper limit of threshold value (12.37%).

**Discussion:** In the CT/MRI department, the small number of air cycling per hour and the frequent use of a face mask with the associated risk of leakage may explain the results. In burn unit patients inhalatory route is also frequent. Desflurane is widely used for its rapid elimination and rapid recovery, which is compatible with the results. Being odorless, it may be connected to undetected escape.

**Conclusion:** The places with more anesthetic agents exposure were the CT/MRI, the ambulatory operating room, and the burn unit. Desflurane was the anesthetic agent more frequently above the upper limit of threshold value. To complement environmental surveillance, it is essential to establish a health surveillance system for professionals exposed to anesthetic agents.

**Keywords:** anesthetic agents, occupational exposure, operating rooms

## Introduction

The adverse effects of anesthetic gases on health are controversial. Reproductive effects are the greatest concern regarding occupational exposure to anesthetic agents, especially the risk of spontaneous abortion, but also teratogenicity, more often associated with exposure to nitrous oxide.<sup>1</sup> In 1977 National Institute for Occupational Safety and Health (NIOSH) issued recommendations on occupational exposure to inhaled anesthetic agents. The guidelines established occupational exposure limit (OEL) values for anesthetic agents available at that time (halothane and nitrous oxide).<sup>2</sup> The need to update the NIOSH guidelines has been referred by several entities and professionals, including the author of the 1974 study, since current OELs may

not guarantee the maximum safety of professionals working with anesthetic agents.

In addition, new anesthetic drugs are now being used for which no OEL is defined, and drug values from the same therapeutic group are used. Regarding the halogenated anesthetic group, only the isoflurane OEL (2 ppm)<sup>2</sup> is published. Environmental monitoring is essential not only for assessing anesthetic gas concentrations but also for measuring the effectiveness of control measures, identifying potential sources of leakage, and adapting the periodicity of medical surveillance according to the results obtained.<sup>3</sup>

In the operating room there are multiple potential sources of leakage of anesthetic gas into the atmosphere, including exhaust valves, ventilator circuit connections, defects in plastic insufflation balloons, or ventilator connectors. The selected anesthetic technique, the type of material used, and unappropriated practices may also contribute to leakage of inhalational anesthetics into ambient air.<sup>4</sup> The operating room is not the only unit in the hospital with anesthetic exposure. The postanesthesia care units (PACU) may have even higher air concentration of anesthetic agents.<sup>5</sup>

The objective of our study was to measure the concentration of waste anesthetic gases in different places of a central hospital in an 11-year follow-up time period.

## Materials and methods

A retrospective study was carried out from the biannual monitoring of nitrous oxide, sevoflurane, and desflurane between 2005 and 2016 in the anesthesiology department operating rooms and in the burn unit of a Central Hospital. Trace gas analysis was performed by infrared spectroscopy.

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In each sample, the concentration of carbon dioxide in ambient air was also measured, because it is a good indicator of air renewal and allows an indirect assessment of the efficiency of the existing ventilation and exhaust system (Heating, Ventilation and Air Conditioning).

The OELs considered were those recommended by NIOSH<sup>1</sup>: 2.5 ppm for nitrous oxide and 2 ppm for sevoflurane and desflurane. In each sample, a stratified analysis was performed by year and by anesthetic agent in each place where they were used.

**Results**

During the 11-year follow-up, 900 samples were taken to determine the concentration of anesthetic agents. In 14.4% of the cases, the concentration of the substances analyzed was higher than the respective OEL. The places with the highest proportion of results exceeding OEL were the CT scan/MRI unit (45.5%), ambulatory operating room (34.5%), burn unit (31.6%), otorhinolaryngology (24.2%), and pediatric surgery (23.9%) (Table 1).

The lower air renewal, associated with increased CO<sub>2</sub> levels, contributed significantly by about 22% to the increase in N<sub>2</sub>O and sevoflurane level (Table 2).

Desflurane was the anesthetic agent with the highest proportion of samples exceeding OEL (12.37%), followed by sevoflurane (11.22%) and nitrous oxide (8.27%) (Fig. 1).

The proportion of nitrous oxide samples was more frequently above the upper limit of threshold in the burn unit of sevoflurane in the CT/MRI and of desflurane in the ambulatory operating room (Fig. 2).

It was observed that since 2010 (year of desflurane introduction in the hospital) and with the exception of the year 2015, there was a trend toward a decrease in the number of samples above OEL (Fig. 3).

**Discussion**

The CT/MRI unit was the place with the highest proportion of samples exceeding OEL (45.5%). In the CT/MRI unit, sedation is required to perform diagnostic tests in multiple situations, such as children and/or noncooperating patients, claustrophobia, or neurological diseases interfering with the technique. Some factors that may justify the results obtained include poor number of air changes per hour and frequent use of an open ventilation system.

**Table 2**

**Regression model for each anesthetic gas with CO<sub>2</sub> levels as a covariant**

	<i>R</i>	<i>P</i>
Nitrous oxide	0.218	<.00133
Desflurane	0.062	>.05
Sevoflurane	0.221	<.001

Usually the examinations performed require short sedation, which avoids invasive manipulation of the airway. Therefore, the use of drugs with rapid elimination is preferred. Thus, It is frequent the use of a face mask with an associated risk of leakage of inhaled anesthetics.

“Ambulatory surgery” is defined as the scheduled surgical intervention, performed under general, locoregional or local anesthesia, regarding admission and discharge of the patient on the same day. A high number of inhalational anesthetics are used to avoid drugs with slow elimination that may delay discharge on the same day as intended. Desflurane is widely used for its rapid elimination and rapid recovery, which is compatible with its high proportion of values exceeding OEL in this place. In burned patients, sedation/general anesthesia is commonly used. These patients present restrictions on the use of intravenous drugs and it is often difficult to obtain intravenous accesses. So, the use of the inhalation route is also frequent as a safe alternative.

In the surgical room of pediatric surgery, there are some peculiarities related to the anesthetic practice that can justify the results obtained, such as the use of noncuff endotracheal tubes and the use of face masks during anesthetic maintenance (due to the difficulty in performing adequate seal).<sup>4</sup> The anesthetic induction by inhalation causes a higher risk of leakage and anesthetic maintenance is done using the sevoflurane (often exclusively).<sup>4</sup> In addition, the ventilation system is also an open system. In pediatric surgery, the PACU is very close to the surgical room and that can contribute to the increase of the aesthetic gases concentration. Three reasons have been proposed to explain this. One, patients who receive volatile anesthetics releases these gases into the environment as they awaken from general anesthesia. Two, PACU have a worse scavenging system, used to collect exhaled medications from the room, than the operating room. Three, PACU contain multiple patients simultaneously who have probably received different aesthetic agents.<sup>5</sup> The otorhinolaryngology surgical room is also

**Table 1**

**Environmental concentrations of anesthetic agents: results above occupational exposure limit (2005–2016)**

Place	Samples (n)	Results higher than OEL-NIOSH	Proportion of results above OEL (%)	Number of air changes per hour
Central surgical room	328	33	10	17.2
Stomatology	36	3	8.3	10.8
Pediatric surgery	46	11	23.9	15.1
Thoracic surgery	64	2	3.13	19.0
Obstetrics	62	5	8.1	25
Ophthalmology	76	10	13.2	33.0
Otolaryngology	62	15	24.2	19.4
Emergency service	76	10	13.2	14.4
CT/MRI	55	25	45.5	7.1
Ambulatory surgery	29	10	34.5	16.6
Burn unit	19	6	31.6	25.8
Digital angiography	17	0	0	14.5
Neurosurgery	30	0	0	37.9
Total	900	30	14.4	–

NIOSH = National Institute for Occupational Safety and Health, OEL = occupational exposure limit.

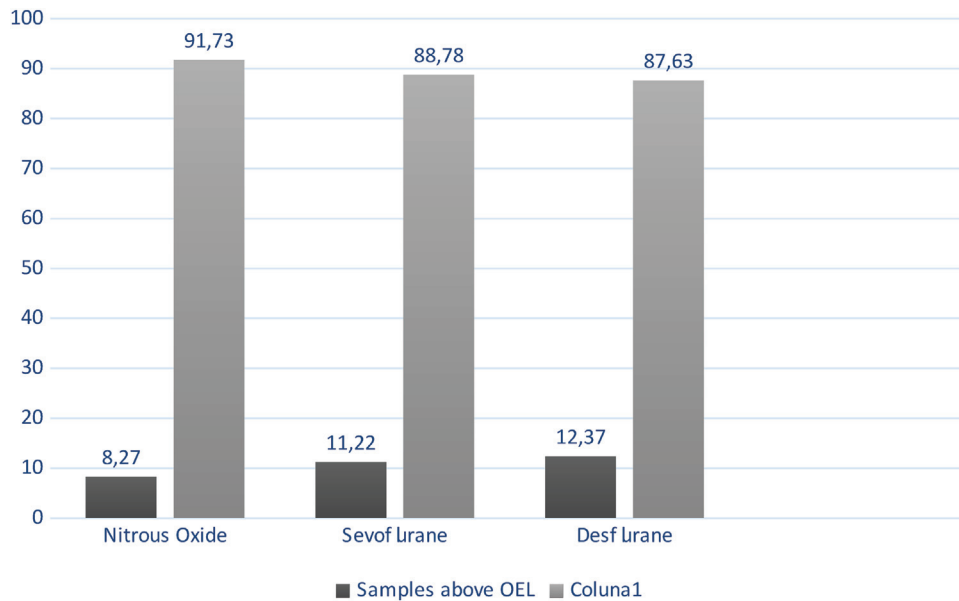


Figure 1. Proportion of results above OEL by anesthetic agent between 2005 and 2016 (%). OEL = occupational exposure limit.

widely used for surgery in children and thus the results are partially explained by the reasons expressed before. As in the pediatric surgery, the PACU is very close to the operating room.

The analysis of Table 1 suggests that inadequate ventilation does not seem to explain the majority of out of limit values, because the number of air changes per hour is higher than that recommended by the *American Institute of Architects of Architecture for Health (AIAAAH, 1996)* in all the places evaluated (except CT/MRI and stomatology).<sup>6</sup> This is also reinforced by the measures of carbon dioxide (only 1.2% of samples exceeded the limit). Also, findings in Table 2 suggest that the high levels of measured anesthetic agents are mainly associated with other situations (beside air renewal). That may include inadequate procedures or leakage.<sup>3</sup>

Desflurane was the anesthetic agent more frequently above the upper limit of threshold value (12.37%), followed by sevoflurane (11.22%) and nitrous oxide (8.27%). The nitrous oxide results may be justified by a greater caution with its management, regarding knowledge about its higher toxicity. The higher proportion of results above OEL regarding desflurane may be explained by the fact that it is odorless (unlike sevoflurane), and leaks are not easily detected by the operating room staff. In addition, the use of desflurane has been increasing, which implies a more recent learning of its handling.

The decrease in the number of number of samples exceeding OEL in recent years (Fig. 3) may be related to the improvement of structural conditions in the surgical rooms and a more differentiated training of their professionals. These results are

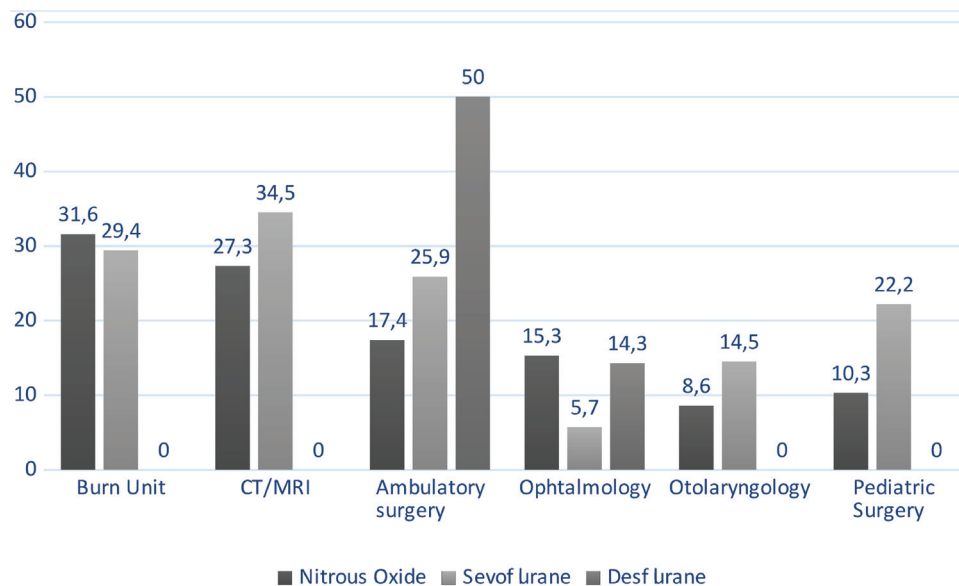
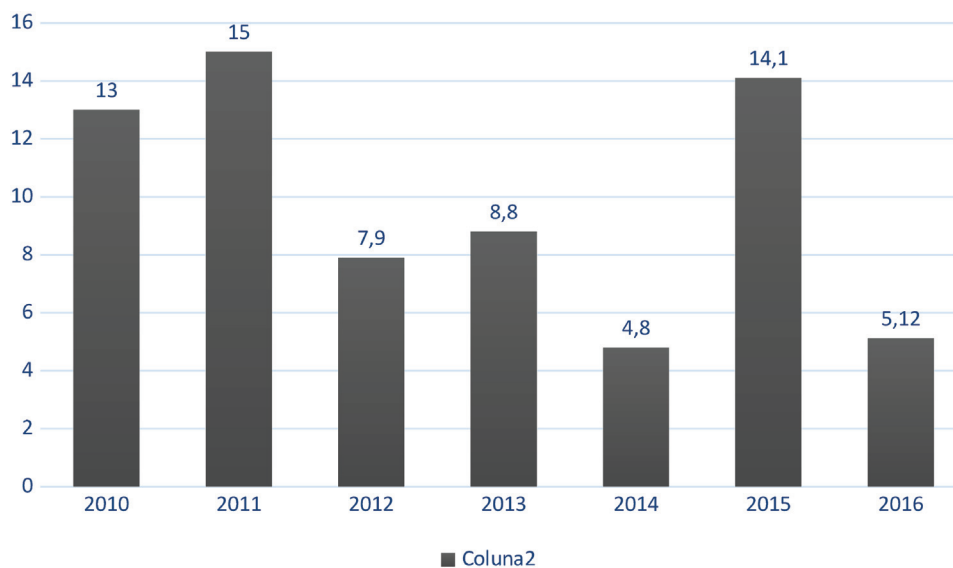


Figure 2. Proportion of results exceeding occupational exposure limit (OEL) by place (%) and anesthetic agent (2005–2016). CT/MRI = computed tomography/magnetic resonance imaging.



**Figure 3.** Evolution of samples above occupational exposure limit (OEL) by year (% 2010–2016).

important to the society. In these specific environments, such actions may help minimize possible risks associated with anesthetic agents exposure, even if published evidence about health effects is still contradicting.<sup>1</sup>

### Conclusions

Our study shows that the places in a central hospital with more anesthetic agents exposure were the CT/MRI, the ambulatory operating room, and the burn unit. Desflurane was the anesthetic agent more frequently above the upper limit of threshold value.

There are many potential sources of anesthetic contamination that must be minimized. To complement environmental surveillance, it is essential to establish a health surveillance system for professionals exposed to these agents. Such actions may help minimize negative health consequences.

### Acknowledgments

None.

### Conflicts of interest

The authors declare no conflicts of interest.

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